AL.1.12.8
C.2

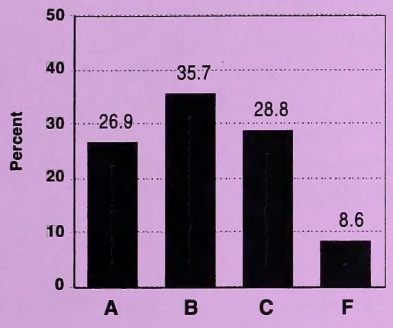
# Chemistry 30

## Diploma Examination Results
## Examiners' Report for June 1994

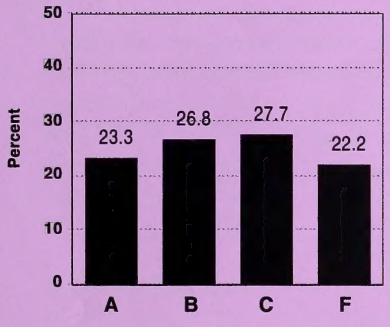
CANADIANA

AUG 9 1995

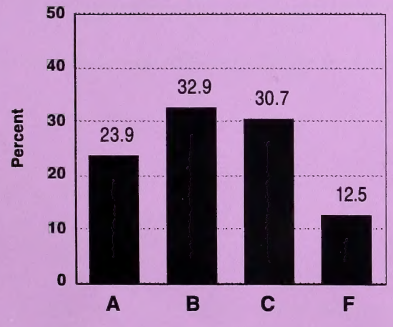
**School-Awarded Mark**




**Diploma Examination Mark**




**Final Course Mark**




The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the June 1994 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

### *Description of the Examination*

The Chemistry 30 Diploma Examination consists of three parts: a multiple-choice section of 42 questions worth 60%, a numerical-response section of seven questions worth 10%, and a written-response section of three questions worth 30% of the total examination mark.

### *Achievement of Standards*

The information reported is based on the final course marks achieved by 7 701 students in Alberta who wrote the June 1994 examination. This represents a decrease of 1 465 compared to June 1993. The decrease is partially accounted for by the fact that 839 students received final course marks in the revised (pilot) Chemistry 30 course.

- 87.5% of the 7 701 students achieved the acceptable standard (a final course mark of 50% or higher).
- 23.9% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Overall, student achievement in Chemistry 30 was acceptable, particularly in knowledge of core concepts. However, students continued to have difficulty with laboratory-related skills and processes, and in organizing and communicating their chemistry knowledge.

Approximately 51.2% of the students who wrote this examination were female, which is similar to the percentage of females in the general population at this age group. There was virtually no difference in the percentage of females and males attaining the acceptable standard on the examination.

Students First!
Student Evaluation

Alberta
EDUCATION

## *Provincial Averages*

- The average school-awarded mark was 68.8%.
- The average diploma examination mark was 64.0%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 66.8%.

Approximately 15.6% of the students who wrote the examination in June 1994 and received a school-awarded mark had written at least one other Chemistry 30 Diploma Examination during the January 1993 to January 1994 period. This subpopulation (1 213) achieved poorer results (61.6%) than the population (6 488) whose first writing of a Chemistry 30 examination (64.4%) was in June 1994. However, the group of students who rewrote the chemistry examination increased their score, on average, from 51.5% to 61.6%.

## *Results and Examiners' Comments*

### *Subtest*

When analyzing detailed examination results, please bear in mind that subtest results cannot be directly compared.

**Results are in average raw scores.**

**Machine scored:** 33.8 out of 49

**Course Content**

- Chemical Energetics 11.0 out of 16
- Acids and Bases: 11.5 out of 17
- Oxidation-Reduction: 11.3 out of 16

**Cognitive Levels**

- Knowledge: 15.7 out of 21
- Comprehension and Application: 16.3 out of 25
- Higher Mental Activities: 1.8 out of 3

**Written Response:** 11.0 out of 21

**Process Skills:** 26.5 out of 46

### *Machine-Scored Blueprint (Multiple Choice & Numerical Response)*

Each question in this section is classified in two ways: according to the curricular content area being tested and according to the cognitive level demanded by the question. The examination blueprint illustrates the distribution of questions in June 1994 according to these classifications. In the machine-scored columns, numbers without parentheses are multiple-choice questions and those in parentheses ( ) are numerical-response questions.

| | Machine Scored | | | |
|---|---|---|---|---|
| **Course Content** | **Knowledge** | **Comprehension and Application** | **Higher Mental Activities** | **Examination Emphasis (%)** |
| Chemical Energetics | 1, 2, 3, 4, 5, 7, (2) | 6, 8, 9, 10, 11, 12, 13, 14, (1) | | 23 |
| Acids and Bases | 15, 17, 18, 19, 21, 25, 27 | 16, 20, 22, 23, 24, 26, 28, (3), (4), (5) | | 24 |
| Oxidation-Reduction | 30, 31, 32, 34, 36, 39, 42 | 33, 35, 37, 38, 40, (7) | 29, 41, (6) | 23 |
| **Examination Emphasis (%)** | 30 | 36 | 4 | 70 |

Note: In the preceeding and adjacent table, those questions which involve the use of science process skills from the multiple-choice section of the examination are 8, 9, 11, 12, 13, 14, 15, 19, 20, 23, 24, 26, 27, 28, 29, 30, 33, 40, and 41; those from the numerical-response section are 1, 2, 3, 5, 6, and 7; those from the written-response section are 1, 2, and 3.

Science process skills received an exam emphasis of 66%.

Cognitive levels received a total examination emphasis of

- Knowledge 30%
- Comprehension and Application 51%
- Higher Mental Activities 19%

## *Teacher-Scored Blueprint (Written Response)*

Each question in this section is designed to measure student achievement of two or more course objectives. Furthermore, students are expected to use a variety of cognitive skills to construct satisfactory responses. The examination blueprint illustrates the distribution of questions in June 1994 according to these classifications.

| Question Number | Teacher Scored<br>Question Description | Examination Emphasis (%) |
|---|---|---|
| 1 | Determining the mass of solute used to prepare a solution and analyzing the reagents involved in successful redox titrations. Communicating clearly and logically. | 11 |
| 2 | Providing a step-by-step experimental procedure to gather data sufficient for identification of a sample. Communicating clearly and logically. | 10 |
| 3 | Predicting the mass of a non-renewable resource required to replace the energy provided by solar heating. Communicating clearly and logically. | 9 |
| **Examination Emphasis (%)** | | 30 |

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable level will obtain a mark of 50% or higher and students capable of achieving the level of excellence will obtain a mark of 80% or higher. Future examinations will continue to require students to demonstrate clarity in their thinking and an understanding of concepts by applying their knowledge to new and novel situations. Students who achieved these expectations were successful on this examination. All future diploma examinations will continue to require students to present their answers in a clear, concise, and organized fashion.

## *Multiple Choice*

| Question | Key | Difficulty* | Question | Key | Difficulty | Question | Key | Difficulty |
|---|---|---|---|---|---|---|---|---|
| 1 | D | 80.1 | 15 | B | 55.1 | 29 | C | 80.9 |
| 2 | C | 76.3 | 16 | C | 84.7 | 30 | B | 43.1 |
| 3 | D | 78.7 | 17 | B | 88.6 | 31 | D | 64.8 |
| 4 | B | 90.0 | 18 | B | 88.2 | 32 | D | 74.7 |
| 5 | A | 67.0 | 19 | A | 87.4 | 33 | D | 87.4 |
| 6 | A | 53.9 | 20 | C | 62.9 | 34 | B | 57.2 |
| 7 | D | 71.5 | 21 | B | 85.7 | 35 | B | 78.8 |
| 8 | C | 96.0 | 22 | A | 80.5 | 36 | D | 88.0 |
| 9 | C | 50.6 | 23 | D | 68.7 | 37 | C | 92.4 |
| 10 | C | 63.1 | 24 | D | 72.5 | 38 | A | 82.6 |
| 11 | B | 44.2 | 25 | B | 72.9 | 39 | B | 80.6 |
| 12 | A | 55.1 | 26 | D | 89.9 | 40 | C | 50.8 |
| 13 | A | 78.7 | 27 | A | 46.6 | 41 | A | 62.7 |
| 14 | A | 54.7 | 28 | A | 32.3 | 42 | C | 75.6 |

*Difficulty—percentage of students answering the question correctly

The following two questions were selected for discussion because they exemplify what is required to meet the acceptable level and the level of excellence.

**22.** A pH meter probe immersed in a solution displays a reading of 4.21. The $[OH^-_{(aq)}]$ of the solution is

- **A.** $1.6 \times 10^{-10}$ mol/L
- **B.** $6.2 \times 10^{-5}$ mol/L
- **C.** $1.6 \times 10^{4}$ mol/L
- **D.** $6.2 \times 10^{9}$ mol/L

**Question 22:** Most students (80.5%) were able to determine that the solution was acidic and as result the hydroxide ion concentration would have to be less than $1.0 \times 10^{-7}$. Only 14.2% of all the students assumed that the solution was basic and hence did not take into account the equilibrium constant for water. Of the students who attained the acceptable standard, 88.2% had success on this question while 98.6% of the students attaining the standard of excellence were successful on this question Students who did not attain the acceptable standard had limited success (42.3%). The results for this question suggest that students who do not attain the acceptable level do not understand fundamental concepts such as pH and relate these concepts stoichiometrically to the equilibrium expression, $K_W$.

*Use the following equations to answer question 28.*

All of these reactions favour products:

$$Bb^-_{(aq)} + H_3O^+_{(aq)} \rightarrow HBb_{(aq)} + H_2O_{(l)}$$
$$Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)} \rightarrow 2CrO_4^{2-}{}_{(aq)} + 2H^+_{(aq)}$$
$$HMo_{(aq)} + OH^-_{(aq)} \rightarrow Mo^-_{(aq)} + H_2O_{(l)}$$

**28.** A physical characteristic that all these reactions share is a

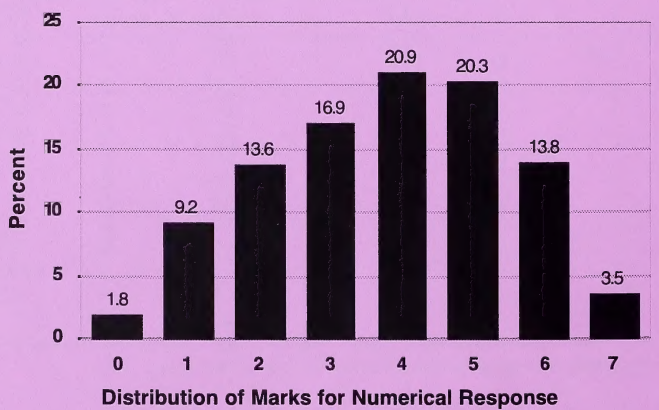
- **A.** yellow colour at the end
- **B.** transfer of $H^+$
- **C.** transfer of $e^-$
- **D.** decrease in electrical conductivity

**Question 28:** Most students (67.7%) could not successfully bring concepts from all three units together to answer this question. The most common mistake made by students (53.6%) was to assume the question involved only one unit; 26.9% believed the question was an acid-base question and 26.5% assumed the question to be based upon the redox unit. The majority of students who attained the standard of excellence (58.3%) were able to answer this question while students who attained the acceptable standard but not the standard of excellence had very limited success (27.6%) and students who did not attain the acceptable standard had very poor success (16.4%) on this question. This result suggests that students who attain the standard of excellence are able to integrate concepts from more than one unit.

## *Numerical Response*

| Question | Answer | Difficulty* |
|---|---|---|
| 1 | 37.6 | 47.3 |
| 2 | 2123 | 93.0 |
| 3 | 1.60 | 64.9 |
| 4 | 20.0 | 54.1 |
| 5 | 2413 | 14.3 |
| 6 | 5867 | 37.2 |
| 7 | 2.26 | 69.0 |

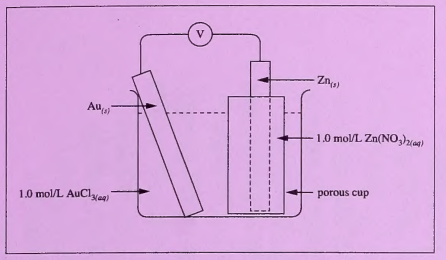
*Difficulty—percentage of students answering the question correctly



Distribution of Marks for Numerical Response

Virtually all students followed correctly the instructions for filling in the answer sheet. Students who did not round their answers as instructed lost marks. The next two questions were selected for discussion because they exemplify what is required to meet the standards.

*Use the following diagram of an electrochemical cell to answer question 7.*




**7.** The reading on the voltmeter is _____ V. (Record your answer to three digits.)

*Use the following information to answer question 5.*

1 - 0.10 mol/L $KOH_{(aq)}$
2 - 0.10 mol/L $H_2SO_{4(aq)}$
3 - 0.10 mol/L $Ba(OH)_{2(aq)}$
4 - 0.10 mol/L $HCl_{(aq)}$

**5.** When these solutions are arranged in order of increasing pH, their order is _____.

**Question 7:** This question discriminated well between weak and average students. Virtually all students who attained the level of excellence (93.0%) were successful. The majority of the students who attained the acceptable level (73.0%) were able to correctly identify the anode and cathode half reactions and then calculate the cell potential. Only 34.2% of the students who did not attain the acceptable level were able to do this. The most common mistake students made (7.2%) was in adding the two reduction half-cell potentials together. The only other mistake identified (2.8%) was in adding the two reduction half-cell potentials together after multiplying the cell potential by the coefficient required to balance the electron exchange. This suggests that students achieving the acceptable level do so because they are capable of selecting half reactions and determining cell potentials.

The average for question 7 was 69.0%.

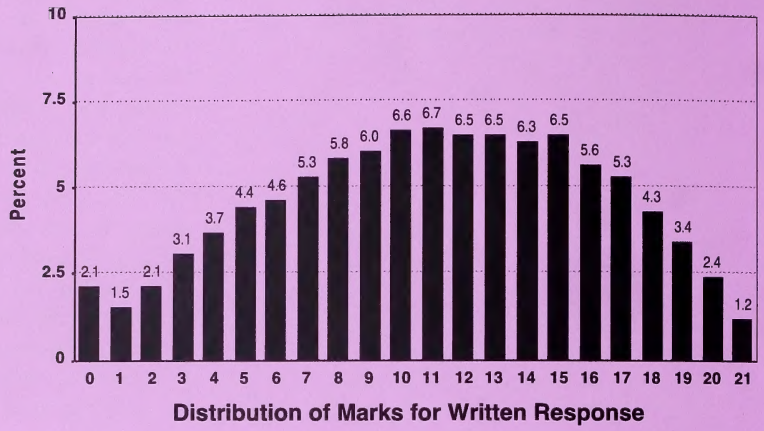
**Question 5:** This question discriminated very well between students who attained the standard of excellence and those who did not. Virtually all the students attaining the level of excellence attempted the question, and 33.4% of them were successful. Very few of the students who attained the acceptable standard but not the standard of excellence (10.4%) and virtually no one who did not attain the acceptable standard (3.6%) were successful in solving this question. The most common mistake (48.9%) was in assuming that hydrochloric acid would have a lower pH than sulphuric acid. Another common mistake was assuming that the higher the pH value, the more acidic the solution would be. As a result, 11.8% of the students ordered their selection backwards. Only 9.2% of the students who made this error had the correct ranking of the substances.

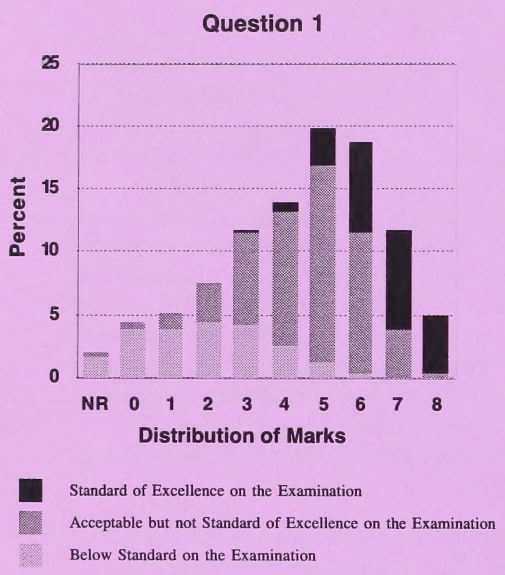
The results for this question suggest that students achieving the level of excellence do so because they are capable of distinguishing between strength and concentration and then relating this to pH.

The average for question 5 was 14.3%.

## *Written Response*

The level of achievement on the written-response section was as expected: slightly more than half of the students (54.7%) achieved a mark of 11 or higher out of 21. The average mark on the written-response section was 11.0 or 52.4% of the available marks.

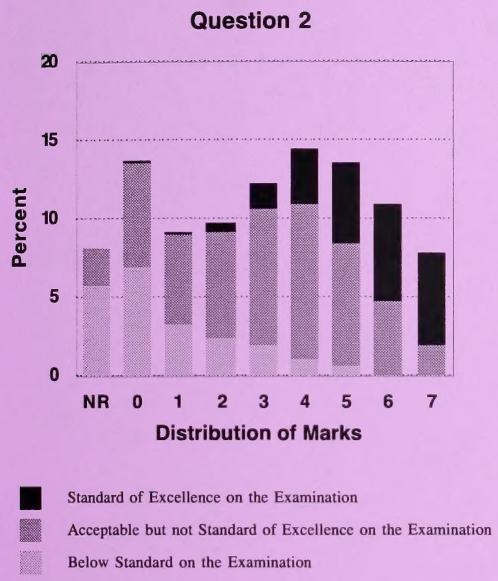



**Question 1** was answered as well as expected. It should be noted that the intent of this question was to distinguish between students below the acceptable level and at the acceptable level. Students who failed to attain the acceptable level on the examination were expected to score 0, 1, or 2 marks on this question and 62.1% did so. They averaged 1.97 marks by writing a net ionic equation and by successfully calculating the standard cell potential for their equation. The most common mistakes this group made were using $Sn_{(aq)} \rightarrow Sn^{2+}{}_{(aq)} + 2e^-$, not balancing their net ionic equation, and assuming that this was an acid-base question. Most of these students were able to identify that acidified dichromate solution is a strong oxidizing agent.

Students who attained the acceptable level but not the level of excellence were expected to score 3, 4, or 5 marks on this question and 61.6% accomplished this. They averaged 4.56 by writing a balanced net ionic equation and correctly performing the stoichiometric process for determining the moles of solute present in the 25.0 mL sample of the solution. They paid careful attention to rounding off to the proper number of significant digits. They had difficulty in determining the mass of solute required to form the solution. In general, they failed to take into account the 500 mL volume of the solution, and instead used the moles of solute present in the 25.0 mL sample to calculate the mass of solute needed. They were successful in identifying two properties that would make acidic dichromate a good choice of oxidizing agent for use in redox titrations but were unable to explain why. Their responses were usually poorly communicated with a wide range of communication errors, such as failing to indicate the states of the reagents and to provide appropriate units in their response.

Students who attained the level of excellence were expected to score 6, 7, or 8 marks and 83.4% attained these marks. They averaged 6.51 by writing the correct equation and performing the necessary calculations. They identified suitable properties and were able to explain why these properties made dichromate a good choice for use in redox titrations.




Their responses were well-organized and their ideas were communicated clearly with essentially no communication errors.

The results on this question suggest that all students attaining the acceptable standard are capable of performing routine calculations, writing balanced net ionic equations, and identifying unique properties of substances.

On this 8-mark question, the average mark was 4.44 or 55.6%.

**Question 2** was not answered as well as expected. This was due in part to the dual purpose of the question. The question was designed to measure students' ability to write a laboratory procedure involving titration and to test their understanding of the variables needed in most acid-base stoichiometry. Students who did not attain the acceptable level were expected to score 0 or 1 and 72.1% did so. They averaged 0.99 by selecting an appropriate indicator and indicating that the experimental procedure should be repeated several times. These students had great difficulty in distinguishing between analysis and procedure, and as a result made statements about how they would analyze the information. Most of these students' responses were ambiguous because they had no idea of what to call the glassware. In general their responses were poorly organized and communicated. Spelling and grammatical errors were the norm.

Students who attained the acceptable level but not the level of excellence on the examination were expected to score around 4 and only 48.4% did so. They averaged 3.02 by writing a titration procedure that could be performed and generate data. However, most students elected to make a solution of the unknown rather than titrating the solid. As a result, they had to indicate how to make a solution of known concentration, which they were unable to do. They also had difficulty in deciding which of the reagents should be placed in the buret and where the indicator should go. They assumed that 1.00 g of the solid had a volume of 1.00 mL, and they had difficulty in coming up with the appropriate name of the glassware that they needed.

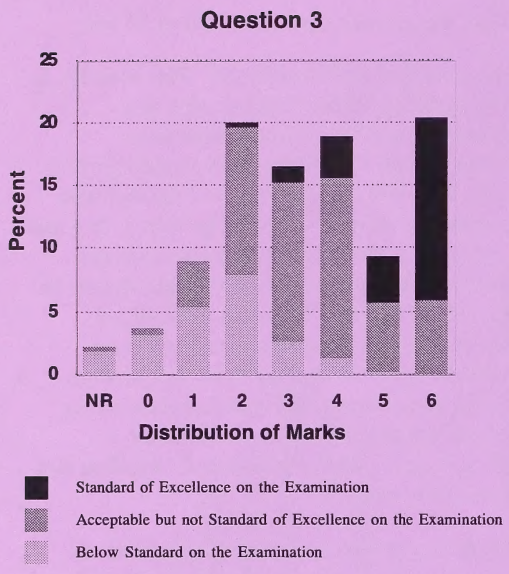
Students who attained the level of excellence were expected to score 6 or 7 marks and only 52.5% did so. They averaged 5.38 by clearly communicating their answers and presenting a procedure that would enable a student to gather sufficient data to determine the molar mass of the unknown. The majority were concise and to the point. The most common mistake this group made was in providing information on how to prepare a solution of known concentration for the unknown sample. Students at the standard of excellence presented valid alternative procedures that did not involve titration. The majority of these procedures involved the use of pH meters or a range of indicators to determine the hydroxide concentration of the unknown. These responses were eligible for full marks. Students electing to answer the question

National Library of Canada
Bibliothèque nationale du Canada
3 3286 50806 3282

this way had the same problem in explaining how to prepare an solution of known concentration for an unidentified sample. Regardless of the approach taken, these students showed good communication and organizational skills.

The results on this question suggest that all students attaining the acceptable standard are capable of writing a titration procedure and of generating data for the determination of a molar mass, and that students who attain the level of excellence can provide valid, non-routine alternative procedures to generate the data. Further, the results suggest that all students, except those at the standard of excellence, could profit from glassware identification and spelling/naming exercises. These problems resulted in a loss of communication/convention marks.

On this 7-mark question, the average mark was 3.13 or 44.6%.




**Question 3** was answered better than expected. Students who did not meet the acceptable level were expected to score up to 2 marks and 82.6% met this expectation. They averaged 1.54 because they knew how to determine the amount of energy involved in warming 50.0 L of water from 11.2°C to 39.0°C . Unfortunately, they were unable to convert the volume of water into a mass of water, and thus generally generated answers of incorrect magnitude. These students had no idea of how to solve the next part of the question, and as a result presented many unique ways to determine the mass of propane needed. As a result, markers had to interpret these students' responses which, in many cases, contained convention errors.

Students who attained the acceptable standard but not the standard of excellence were expected to score up to 4 marks and scored, on average, 3.40. In total, 79.0% of these students met this expectation. They correctly determined the amount of energy involved in warming the water and knew how to determine the amount of propane needed. However, most of these students did not recognize that the molar heat of formation of propane is not the same as the molar heat of combustion for propane. As a result, they were unable to generate a correct response. These students were able to communicate their ideas well enough to the markers so that little, if any, interpretation was required.

Students who attained the level of excellence were expected to score 6 marks and scored, on average, 5.31 for this question, with 62.1% attaining a perfect score. They answered the question well. The only area of weakness noted was careless errors involving significant digits, units, and appropriate states of matter. These students presented their answers in a concise, organized fashion and expressed themselves clearly to the markers so that no interpretation was required.

The results on this question suggest that all students attaining the acceptable standard are capable of determining the heat of reaction using Hess's Law, determining the amount of energy required to change the temperature of water, and using these concepts to determine the mass of a substance required to cause the desired change.

On this 6-mark question, the average mark was 3.40 or 56.7%.

For further information, contact Don Loerke or Lowell Hackman at the Student Evaluation Branch, 403-427-0010.